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in a zone of 21 to 25 tiers. In vertical section the folds of the foliate organs show 5 to 20 rows of bulbs. *Equus asinus*, like the horse and mule, has two circumvallate papillae and foliate organs. The taste-bulbs are long and narrow, and those of the circumvallate papillae are arranged in a girdle of 5 to 10 tiers. The folds of the foliate areas contain 5 to 10 rows of bulbs. In *Cricetus frumentarius* the foliate type of taste organ is present, but circumvallate areas are lacking, although Mayer mentions finding a single circumvallate papilla in the hamster. The folds of the papillae foliatae bear from 2 to 10 rows of nearly spherical bulbs. *Sus scrofa*, like the domesticated pigs, possesses two circumvallate papillae and foliate structures. In the former region the bulbs are long and narrow, and the tiers vary in number from 7 to 25. The folds of the foliate papilla show 5 to 16 rows of bulbs. In *Mus sylvaticus* there is but one circumvallate papilla, while *Myoxus avellanarius* possesses three papillae of this type. In neither of these species, apparently, was a thorough search made for foliate taste areas. In none of the animals investigated were taste-bulbs detected in the epithelium of the upper surface of the circumvallate or foliate papillae, nor were any found in that lining the outer wall of the trenches encircling the former. Hönigschmied found fungiform papillae bearing taste-bulbs in *E. asinus*, *S. scrofa*, *C. frumentarius* and *M. avellanarius*. Both Hönigschmied and Brücher regard the circumvallate papillae as modifications of the fungiform type. While this hypothesis may be true in the case of certain individual papillae, it seems highly probable that the circumvallate papilla, as a distinct taste area, has been developed through a long series from the gustatory or bulb-bearing ridges. These ridges, which have been found in *Ornithorhynchus anatinus* and *Belandreus ariel*, are probably the nearest approach among living animals to the primitive type of gustatory area of Mammalia, and are doubtless the forerunners of the circumvallate type of papilla.

F. T.

## II.—EXPERIMENTAL.

*Ueber die Helligkeitsempfindung im indirekten Sehen.* A. KIRSCHMANN.  
Philosophische Studien, V, 3, pp. 447–497.

Kirschmann, without having seen the work of A. E. Fick, examined the lateral portion of the retina in regard to its sensitiveness to brightness. His results are of a different nature from Fick's, for his eyes were examined under ordinary conditions, and Fick's only after prolonged adaptation. He finds an increase of sensitiveness amounting to a fraction of the whole—one-seventh for  $20^{\circ}$  away from the center—while Fick found a sensitiveness fifteen times as great as at the center. The latter result is plainly very different from anything which takes place under ordinary conditions, or we should not fail to be easily aware of it.

The different parts of the retina differ in respect to (1) the distinctness, (2) the quality, and (3) the intensity of the sensations which they convey. (1) On account of the unfavorable conditions for refraction and accommodation, the images on the side parts of the retina are not good; but this alone is not enough to account for the degree of indistinctness of vision that prevails there—the eyes of

rabbits, for instance, are such that very sharp images are formed in the periphery. It is necessary to assume therefore that the diminished number of nerve-ends is an additional cause. (2) There is an important modification of the color-sense towards the periphery; at a certain distance blue and yellow only are seen, and farther away no color at all is distinguished. But the changes which colors undergo as they are looked at peripherally are very different from those which are caused by a diminished brightness; red becomes orange when it is looked at with the periphery, but when looked at in a faint light, black; neutral violet becomes blue and gray respectively. Hence a diminished brightness cannot be the cause of the change. (3) That a diminished brightness does not occur on the border is made plain by these experiments. Two black and white rotating disks were looked at, one with the fovea and one with some other portion of the retina, and black was added to the latter until it looked no brighter than the former. A maximum sensibility was found at a distance of  $20^{\circ}$ — $25^{\circ}$  in a horizontal direction, and  $12^{\circ}$ — $15^{\circ}$  in a vertical direction. The increase of sensibility is much greater horizontally than vertically. An interesting fact is that the lower portion of the retina is less sensitive to brightness than the upper portion. We have no occasion to notice slight changes of brightness in the sky, but it is essential to safe moving about that unusual things on the ground should attract our attention.

Kirschmann draws attention to the fact that the cone of light which can enter the pupil from an object far to one side is very thin, and hence that the objective brightness of things seen laterally is diminished in the ratio of the cosine of the angle, if the object is far away. Hence the actual increase in sensibility in the lateral portion of the retina must be greater than the apparent increase by an amount enough to make up for this objective decrease of brightness. After taking account of this, the curve of increase is found to be a straight line. The cause of this greater feeling for brightness in the non-foveal portion of the retina he finds in the supposition that the end-members of the rods, which are much more developed than those of the cones, act as reflecting mirrors to send some light back upon the nerve-terminations. It remains to be found out whether the rods are most numerous at the place where he finds the maximum sensibility.

An interesting fact which appears from his tables, but which Kirschmann himself does not mention, is that for bright objects (the background was constant, 270 black + 90 white) the nasal portion of the retina is decidedly better than the temporal. This is a difference which, as Schön has shown, is of great importance in enabling us to determine whether a given pair of double images belong to an object without or within the horopter—so great that by an artificial alteration in the relative brightness of the images an error of judgment in this respect may be produced. C. L. F.

*Ueber den Lichtsinn der Netzhautperipherie.* TREITEL. Arch. f. Ophth. XXXV, 1, p. 50.

This is the third independent investigation into the sensibility of the lateral portions of the retina that has been made within a very short time, and the difficulty of the subject is apparent from the fact that all three investigators, A. E. Fick, Kirschmann and Treitel, have obtained very different results. Treitel finds the lateral portion less